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PHENOTYPIC CHARACTERIZATION OF COMMERCIAL AND ROOTSTOCK AVOCADO VARIETIES

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The objective of the present paper was to characterize 15 avocado varieties to increase the information available for this fruit. Fifteen avocado varieties from the United States Department of agriculture Germplasm Repository System, at Miami, FL: Utuado, Vero Beach, Aycock, Brooks, Collins, Cellon's Hawaii Seedling, Winslowson, Vero Beach No. 1, Tonnage, Melendez, Semille 36, Lima late, Collison and Lula were characterized for; weight; length, width, and fruit shape; and peel characteristics (roughness, color and hand peeling); flowering dates (for bud, bloom, bloom and fruit and fruit). Differences in fruit number and fruit weight were found. Most of the varieties were ovate, with rough green peel and easy to hand peel.

Key words: avocado, fruit characterization, germplasm.

CARACTERIZACIÓN FENOTÍPICA DE VARIEDADES DE AGUACATE COMERCIAL Y PARA USO DE PATRON CLONAL

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El objetivo del presente documento es caracterizar 15 variedades de aguacate para aumentar la información disponible para esta fruta. Quince variedades de aguacate del Banco de Germoplasma del Ministerio de Agricultura de Estados Unidos, en Miami, FL: Utuado, playa de Vero, Aycock, Brooks, Collins, Plantula de Cellon de Hawaii, Winslowson, Vero Beach 1, Tonnage, Melendez, Semille 36, Lima Late, Collison y Lula fueron caracterizados en distintos aspectos: peso, longitud, ancho, y forma de la fruta; y características de la cáscara (aspereza, color y peladura manual); fechas de floración (para el brote, flor, flor y fruta). Se detectaron diferencias en el número y peso de la fruta. La mayor parte de las variedades eran ovaladas, con la cáscara verde áspera y fácil de remover con la mano.

Palabras claves: palta, caracterización de fruta, germoplasma

1. Introduction

Avocado (*Persea americana* Mill.) is a popular fruit in the United States being cultivated in this country in Florida since 1833 when the first trees were sent from

Mexico by Mr. Henry Perrine (Toy, 1931). Although the United States is in the third place among the world producers, there are few specialized orchards. Interest in avocado to choose the best varieties began in the 1900's (Toy,1931).

Avocado varieties are classified in three groups, known as the West Indian, Guatemalan and Mexican "races". West Indian avocados originated in the tropical lowland areas of southern Mexico and Central America whereas the Guatemalan and Mexican avocados originated in mid-altitude highlands in Guatemala and Mexico (Crane et al., 2005). Selection of varieties must include various strategies, a broad list being given below. One approach is quite variable and depends on the climatic and soil conditions as soil drainage (Avilán & Rodríguez, 1992). Another could be to find high yielding varieties, with low vulnerability to diseases (Knight Junior, 1999), climate conditions and selection of rootstocks (Ben-Ya'acov et al., 1992); and consumer requirements, such as minimum or maximum oil content according to amended dry weight procedures (Florida Growers, 1989/1990). Additional characteristics are size, color, peel roughness and shape depending on consumer preference (Hoffman et al.,2002); flavor (Lewis et al., 1979), amount of pulp fiber (Rouse & Knight Junior, 1991), pulp tendency to brown (Lizana & Luza, 1979), and facility of hand peeling etc. Further characteristics must be considered when production is oriented to the fresh or processed product market as a high pulp yield (Rouse & Knight Junior, 1991) or to oil yield (Swisher, 1988).

The objective of this work was to provide information of many varieties that have not been reported and to complement the agronomic studies in order to make an information data bank useful to growers and researchers.

2. Materials and Methods

All samples were collected from plants maintained at the National Germplasm Repository (NGR), Miami, Florida, whose location and characteristics have been indicated previously (Ayala-Silva et al. 2005). Fifty mature fruits of each of the following avocado varieties from trees at least ten years old were harvested: Aycock, Brooks, Cellon's Hawaii Seedling, Collins, Collinson, Lima Late, Lula, Melendez, Semille 34,Tonnage, Utuado, Vero Beach GRD, Vero Beach No. 1, Winslowson, and Wilson Popenoe. The samples were taken to the laboratory and kept in room temperatures conditions until ripe. Fruits were considered ripe, when its skin was ruptured with a 0,8 cm width cylindrical plunger in an Instrom Universal Testing Machine model 1101. Ten fruits of each variety were measured to obtain fruit size. When samples were ripe, ten fruits of each variety were randomly selected, and analytical determinations were performed.

Fruit weight (whole fruit, seed, and pulp) was measured on a digital scale (grams) and recorded. Fruit length was measured (cm) with a ruler mounted on plexi-glass fixed slide rule and recorded. Shape and the peel characteristics roughness, hand peeling, and color were determined. Flowering type and flowering season of the aforementioned avocado Varieties is also reported.

Skin color results are the average of ten readings taken equidistantly at the equator of the fruit, measured with a colorimeter using the LAB System (Ayala-silva and Meerow., 2005).

Color measurements of avocadoes were made using a portable CR-400 tristimulus colorimeter (Minolta Chroma Meter CR 400, Osaka, Japan) and SpectraMatch software, set to L*, a*, b* mode. The colorimeter has a beam diameter of 8 mm, three response detectors set at 0 viewing angle and a CIE (International Commission on) standard illuminant C with diffuse illumination. This illuminant is accepted as having a spectral radiant power distribution closest to reflected diffuse daylight. A white plate was used for calibration (L*= 98.15, C*= 1.92, h°*= 93.8, a*=–0.13, b*= 1.92).

Color changes were documented over the duration of the experiment. L* values indicate lightness (black [L*=0] and white [L*=100]), a* values indicate redness-greenness (red [a* = 100] and green [a*={-100}]), b* values indicate yellowness-blueness (yellow [b* = 100] and blue [b*={-100}]). The L* a* and b* values obtained from each avocado at the time of sampling represent average L* a* and b* values calculated from three separate light pulses from the colorimeter. Descriptive analysis and statistical models (ANOVA and mean separation) were performed using the Univariate procedures of PC-SAS version 9.1 (SAS Institute, Cary, N.C.), respectively.

3. Results and Discussion

Only data on four varieties Lula, Collinson, Wilson Popenoe and Winslowson (Gomez-Lopez 2002 and 2002) were found in the literature, this may be the first time that the other varieties are reported. Comparing data on fruit characteristics from different environments is very difficult because different factors can induce variability even in the same location and at different harvesting seasons (Salazar et al., 1971), but there is no other way to compare data from different locations.

According to data obtained (Table 1), all of the Varieties flowering from December to May were divided into early, middle, and late flowering groups. The flowering period of 'Vero Beach GRD', 'Winslowson, 'Wilson Popenoe', and Cellon's Hawaii seedling, were the earliest flowering Varieties, they begins in early December and ends in late March. 'Vero Beach GRD' flowers earlier than 'Utuado' which blooms from mid-December to early April. 'Lima Late', 'Collison'and 'Aycock Red', and 'Tonnage' which belong to the middle flowering group, bloom from late January to late April. The flowering periods of the late flowering Varieties, which include 'Brooks Late',and 'Melendez', are from late February to mid-May. The full bloom period of the varieties ranged between seven weeks to five months. Only one Variety (Tonnage) lasted under seven weeks. Following the flowering dates and IPGR (1995) descriptors, eight varieties demonstrated an A flowering type, and seven shown a B flowering type (Table 1).

Wilson Popenoe, Lula and Collinson were heavier than the range of weights reported by the Florida Avocado Society (Florida Growers, 1989/1990) and those

reported by Gomez-Lopez (2000 and 2002) en Venezuela. However, Winslowson shown a lighter weight than the weight registered by Salazar et al.,1971 (Table 2). Wilson Popenoe, Lima Late, Cellon's Hawai seedling and Melendez demonstrated to be very heavy; whereas Vero Beach GRD, Brooks Late and Collins showed the lighter weigth (Table 2).

Wilson Popenoe and Cellon's Hawaii seedling were the varieties with the highest pulp proportion ($p < 0.05$) in this group (Table 2) and among the 15 varieties evaluated from the repository. This weight was superior than the values reached by varieties from other places, like Venezuela (Gomez-Lopez, 2000 and 2002) and Cuba. Vero Beach, Aycock and Lula showed the lowest weigth (Table 2).

In accordance with the descriptors used by Biodiversity International (IPGR, 1995), four varieties were high-spheroid, two spheroid, three ovobate, two narrow-obovate,three pyriform and one cucumber shaped (Table 3). Nine Varieties had smooth, four rough and two semi-rough texture. The rough texture is related to the development of extensive corky areas in the external fruit surface (Schroeder, 1950) rather than the irregular surface exemplified by the Lula or Brooks Late varieties. Five varieties had purple peel (positive chromaticity value ***a***, Table 3), which might be due to anthocyanin pigments as was reported by Prabha et al. (1980), two varieties had yellowish skin and the other varieties were green (negative chromaticity value a).

The varieties used in this work were easy to hand peel, excluding Brooks Late, Collins, and Collinson. The first one had a very adherent peel, and the others a very adherent and easy to brake peel.

Peak ripeness time, the after harvest time when the highest amount of samples of each variety ripen (Storey et al.,1973, Lee, 1982, Bergh et al.,1989), was 3 days for Cellon's Hawai Seedling; Wilson Popenoe; Vero Beach GRD, Vero Beach 1, and 4-6 days for the others. This data could be useful to select comercial varieties because the later the peak ripening, the longer the storage life. In addition, consumers prefer avocados with dark skin than a green skin.

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Table 2. Fruit weigth, diameter, pulp, seed, and skin peel of 15 avocado varieties from the NGR at Miami, FL.

Variety	Weight (g)	Diameter (cm)	Pulp (g)	Seed (g)	Skin Peeling
Aycock	359.20	85.28	231.2	57.72	Easy
Brooks	215.8	74.02	NR[Y]	55.22	Hard
Cellon's Hawai Seedling	747.76	101.26	635.3	65.46	Easy
Collins	347.76	80.06	250.82	76.94	Hard
Collison	412.08	92.04	NR	72.78	Hard
Lima late	1053.3	105.00	NR	134.30	Easy
Lula	450.8	87.38	278.8	95.24	Easy
Melendez	682.21	96.57	NR	111.07	Hard
Semil34	504.88	94.4	NR	77.00	Easy
Tonnage	517.42	89.03	NR	68.39	Easy
Utuado	556.64	95.78	NR	112.64	Easy
Vero Beach GRD	256.6	72.36	174.44	57.16	Easy
Vero Beach 1	390.7	89.54	289.96	70.74	Easy
Winslowson	478.22	89.96	NR	68.44	Semi-hard
Wilson Popenoe	1028.14	90.68	858.0	55.88	Easy

[Y]NR=Not reported. Data are means of 50 fruits

Table 1 Race, Flower type, time to bloom and fruit, MIA/PI number

Variety	[X]Race	[b]Flower type	Flowering period		Time to full bloom		MIA No.
			Date (month/date)	Weeks to flowering	Date (month/date)	Weeks to full bloom[Y]	
Aycock red	WI	B	1/20-5/21	17	1/20-5/10	16	MIA20022
Brooks	G	B	2/26-4/23	14	2/26-4/16	13	MIA22618
Cellon's Hawai seedling	WI	B	1/11-4/7	12	1/11-4/1	11	MIA 6915
Collins	GXWI	B	1/5/-3/25	10	1/5/-3/18	9	MIA 3897
Collinson	GxWI	A	1/26-4/22	12	1/26-4/16	11	MIA 400
Lima late	MXWI	B	2/2-5/10	17	2/2-4/30	16	MIA20034
Lula	MxG	A	1/26-5/10	9	3/18-4/30	8	MIA7828
Melendez	GXWI	A	1/11-4/22	12	1/26-4/16	11	MIA19770
Semil34	GXWI	B	2/2-4/14	11	2/2-4/7	10	MIA24224
Tonnage	GXW	B	1/26-3/12	7	1/26-3/5	6	MIA 19847
Utuado	GXWI	A	1/26-4/7	11	1/26-4/7	10	MIA 19768
Vero Beach GRD	CH	B	1/5/-3/25	10	1/5/-3/18	9	MIA 20536
Vero Beach #1	CH	A	12/9-4/16	16	12/9-3/5	12	MIA18435
Winslowson	GxWI	B	1/5/-5/21	20	1/5/-5/14	19	MIA 3888
Wilson Popenoe	WI	A	1/20-4/7	12	1/20-3/31	11	MIA21135

[X] M= Mexican, WI= West Indian, G=Guatemalan, MxG= Mexican cross with Guatemalan GxWI= Guatemalan-West Indian and CH=complex hybrid. [Y]Full bloom'
defined as more than 75% flower bud were flowering.

Table 3. Shape, texture and color characteristics of 15 avocado varieties from the USDA, ARS germplasm repository, Miami, FL, USA.

Variety	Shape[b]	Texture	L^X	a^Y	b^Z
Aycock	Ellipsoid (4)	Soft	42.65	-4.83	13.16
Brooks	Spheroid (2)	Rough	38.45	-6.67	7.70
Cellon's HI Sdlg	High spheroid (3)	Soft	42.15	-4.80	12.49
Collins	High spheroid (3)	Soft	35.92	2.16	3.42
Collison	Narrowly obovate (5)	Soft	37.35	-1.94	6.58
Lima late	Ovobate (6)	Soft	38.33	-3.12	8.71
Lula	Pyriform (7)	Rough	39.34	-8.99	12.13
Melendez	Ovobate (6)	Soft	40.35	-4.96	11.87
Semil34	Spheroid (2) to	Semi-rough	41.29	-10.53	15.04
Tonnage	Pyriform (7)	Rough	42.76	-9.29	13.72
Utuado	Narrowly obovate (5)	Semi-soft	41.91	-10.95	13.16
Vero Beach GRD	High spheroid (3)	Soft	33.99	2.93	1.65
Vero Beach 1	High spheroid (3)	Soft	34.69	4.07	1.95
Wisloson	Ovobate (6)	Rough	39.92	-3.02	9.61
Wilson Popenoe	Clavate (8)	Soft	46.95	-8.17	17.03

[b]based on descriptors (IPGR, 1995). [X]lightness, [Y]red/green chromaticity, [Z]yellow blue chromaticity.